A REMARKABLE OCCURRENCE OF CALCITE IN SILICIFIED WOOD.

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The material here described was collected by Mrs. Charles D. Walcott in Yellowstone National Park during the summer of 1915. It is dark brown in color and shows, even to the naked eye, unmistakable vegetable fiber. Dotted through the mass are minute white grains, with rhombic crystal outlines, and with dark central nuclei. The wood has been examined by Dr. F. H. Knowlton and identified as *Sequoia magnifica* Knowlton.[1] The major part of the replacing material is silica, but the crystal grains are calcite, and the features shown by the latter mineral are so unusual that a special study of it has been made.

When thin sections are examined under the microscope the positions of the calcite grains are found to bear no definite relation to the wood structure; they cut across the cells in all directions. They are bounded by somewhat convex crystal planes; by measuring the angle between the trace of the vertical axis (located by the interference figure in convergent polarized light), and these planes, in a number of grains lying on their sides, the dominant form was determined to be *e*, the half negative rhombohedron: observed 24–26°, calculated 26° 15′. The base, *c*, is sometimes obscurely developed, as is also the unit rhombohedron *r*. A few of the grains are single crystals, but the majority of them are formed by the intergrowth of several crystals. The individuals appear always to be intergrown in twinning position, the twinning plane being *r*, the unit rhombohedron, the vertical axes accordingly making angles of 90° 46′ with one another, and extinction in the two parts of the twin being at times nearly simultaneous. This twinning is often polysynthetic, several thin lamellae making up the central part of the grain, while the outermost portions develop normally. Complicated multiple twins also occur.

[1] Knowlton, F. H., Fossil flora of the Yellowstone National Park. U. S. Geol. Surv. Mon. 32, pt. 2, 1899, p. 761, pls. 104, 105, 110, 111, and 117, figs. 1–6.

The most interesting features of these calcites are their inclusions and exclusions of wood fiber. The relations of these can be best appreciated by reference to the illustrations accompanying this article. Their main features may be summed up here. Toward the center of each grain a portion of the wood fiber is preserved as an inclusion. The cells have not been greatly distorted, but the outlines of the groups of cells are determined by the crystallographic character of the grains. As a result of the elongation of inclusions in polysynthetic twinning lamellae curious symmetrical figures have been produced, some of them resembling insects. The cells are completely enveloped in calcite substance, and no silica has been observed in any of the included portions of wood.

Surrounding the central group of wood cells there is usually a zone of entirely clear calcite, although in some instances the cells extend outward and are continuous with those outside the crystal. Toward the outer edge of the clear zone there is usually a band of very minute, disrupted fragments of cells; and these often descend along the boundaries of twinning lamellae into the mass of undisturbed cells at the center.

The margins of the crystals are generally sharply outlined against the darker wood, and the crystal faces are always distinctly curved. The phenomena exhibited outside the crystals are also noteworthy. In all cases where any considerable proportion of a calcite crystal is clear a dense black rim surrounds it. This is evidently composed of wood cell material crowded out of the growing crystal. The wood structure just beyond this rim is sometimes curved around the crystals, although usually no effect whatever can be observed. These relations show that the wood must have been decomposed to such an extent that it soaked up the solutions as does a sponge, and had lost practically all rigidity, so that compression exerted by growing crystals produced no effect beyond the cells in the immediate neighborhood of the crystals.

Outside of the calcite crystals the wood cells are, in general, very well preserved as dark-brown carbonaceous matter. Between crossed nicols all openings are seen to be completely filled with quartz, an individual crystal occupying each cell. The deposition of this has evidently taken place from solutions which permeated the whole cell structure; and since crystallization occurred about as rapidly on one side of a cell wall as on the other, the structure was not distorted thereby.

A certain amount of distortion is shown by the wood cells, but it is of such a type as to indicate that it was produced by the pressure of overlying sediment on the rotted wood, rather than by the growing of crystals. If anything the cells included in the calcite grains are

less affected than those without, indicating that the growth of the calcite took place fairly early in the history of the specimen.

That the calcite was the first mineral to form is shown by the facts that its grains possess crystal outline and inclose only woody matter, never silica. When calcite crystallizes from solutions contained in the pore spaces between grains of sand it frequently incloses the latter, yielding "sand calcites," of which many occurrences have been described. In the present instance the wood, in the process of decay, evidently became saturated with a solution capable of depositing calcite, and wood cells were inclosed, much as are the sand grains in the "sand calcites."

The only reasonable hypothesis which suggests itself to account for the outer portions of the crystals excluding wood cells instead of including them is that of decrease in rate of crystallization. It is well known in the study of crystallization that the rapid formation of crystals renders them particularly likely to inclose mother liquor, gas bubbles, or foreign particles suspended in the solution; slow formation, on the other hand, furnishes opportunity for the growing crystals to push aside such obstacles. According to this view the solutions percolating into the decomposing wood were at first well saturated with calcium carbonate, and when crystallization was inaugurated—perhaps by warming, by changes in pressure, or by removal of carbon dioxide through the agency of bacteria—it went ahead at first at a relatively rapid rate. The wood cells were at this time included in the crystals.

As the solutions became depleted in calcium carbonate, however, the rate of crystallization naturally slowed down and exclusion of the cells took place. In time growth ceased, and a rim of cell material surrounded the crystals. Then a slight renewal of calcium carbonate in the solution occurred, and a thin layer of crystal matter deposited over the surface of the previously formed crystals; this also excluded most of the cell matter in its path, but traces remained behind to mark the level of temporary cessation of growth. Silica solutions then flowed in, and all remaining cavities were filled by quartz.

EXPLANATION OF PLATES.

On the plates are shown photomicrographs of thin sections of the wood containing calcite crystals.

PLATE 29.

(Enlarged 10 times.)

Shows simple and twinned crystals, different forms of inclusions, the lack of influence of the wood structure on the directions of crystal growth, and the lack of distortion of the wood cells by the crystals.

PLATE 30.

(Enlarged 20 times.)

FIG. 1. Shows at top a simple crystal with central inclusion, outer clear zone, and thin line of dark matter near margin, the heaping up of a dark rim at sides, and the slight parting of the cells at either end. Near the bottom a twinned crystal, with the inclusion continuous with the outer cells at one end and partitioned among the twinning lamellae at the other; the lack of distortion of the cells is evident.

FIG. 2. Shows near center large irregularly twinned crystals, with the included cells partially continuous with those outside, but greater distortion toward the margin than in the center of the crystal.

PLATE 31.

(Enlarged 20 times.)

FIG. 1 (part of Plate 29, further enlarged). Shows compound twin crystals with marked partition of inclusions among the several parts of the twins, yielding insectlike forms. The dark rims of excluded cell material are also well developed.

FIG. 2. Shows symmetrical partition of inclusion in a "fish tail" twin crystal.

FIG. 3. Shows at top a crystal seen end on, the central inclusion being slightly eccentric. Below, a multiple twin with unusually faint inclusions.

SILICIFIED WOOD CONTAINING CALCITE.

FOR EXPLANATION OF PLATE SEE PAGE 229.

1

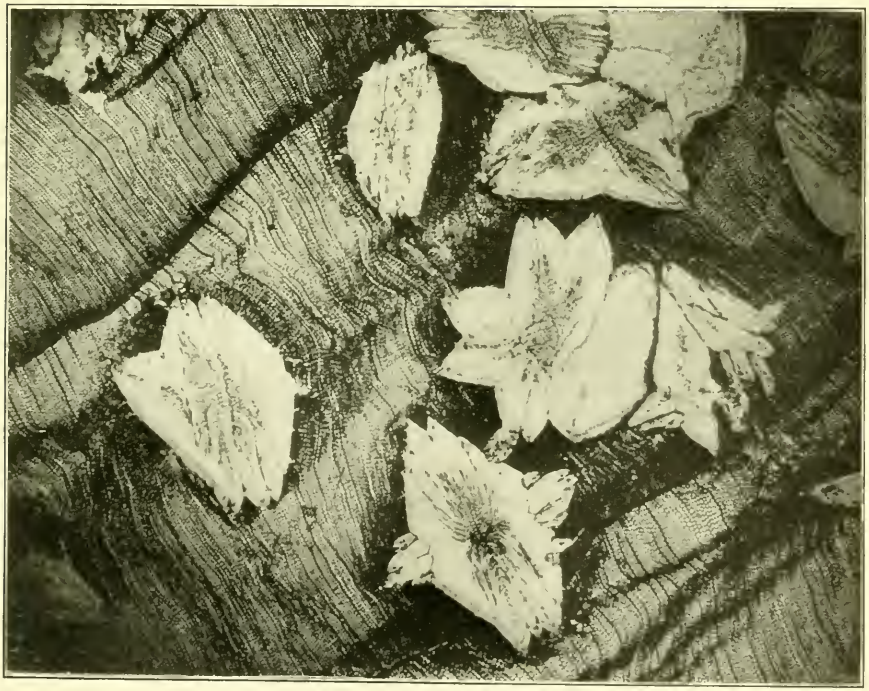
2

SILICIFIED WOOD CONTAINING CALCITE.

FOR EXPLANATION OF PLATE SEE PAGE 230.

1

2



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SILICIFIED WOOD CONTAINING CALCITE.

FOR EXPLANATION OF PLATE SEE PAGE 230.